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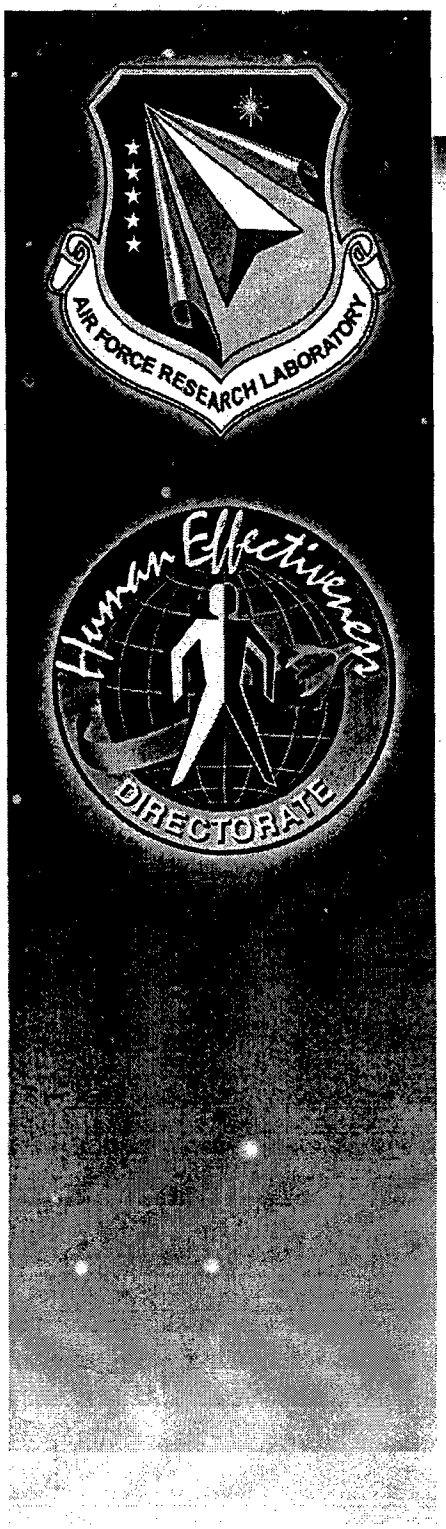

Effects-based Assessment

Maris McCrabb

DMM Ventures, Inc.
107 Elise Place
Yorktown, VA 23693

September 2005

Interim Technical Memo for October 2004 to September 2005

Human Effectiveness Directorate
Warfighter Interface Division
Cognitive Systems Branch
2698 G Street
Wright-Patterson AFB OH 45433-7604

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FOR THE DIRECTOR

//SIGNED//

MARIS M. VIKMANIS
Chief, Warfighter Interface Division
Human Effectiveness Directorate

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14. ABSTRACT

This Technical Memo presents and early exploration of the implications of effects-based Operations doctrine on combat assessment functions.

15. SUBJECT TERMS
Effects-based Operations, Effects-based Assessment, Combat Air

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Effects-based Assessment: A Research Memo

I. Introduction, Motivation & Audience. Key to taking an effects-based approach to conflict is an ability to assess the outcomes—or effects—of actions taken to achieve those effects. Historically, assessment activities focused on the actions themselves and, at best, on progress towards achieving specific objectives, normally tactical objectives at component levels and operational and campaign (or theater) objectives at the Joint Task Force or Combatant Command level. The motivation for this research memo is to explore one way effects-based assessment (EBA) can be modeled. There is no attempt here to definitize an EBA process or completely identify necessary information requirements for an EBA model. The main audience for this memo is technology developers who might require some process and information requirements to begin designing technologies that might support that process. One would hope and expect through this research effort to identify different ways and means of conducting EBA all with the same end state of providing decision support technologies for EBA.

This memo proceeds as follows. First working definitions are provided then EBA is explained from the current state-of-practice to an EBA approach to assessment. The main part of this memo offers one approach to constructing an EBA model that outlines the inputs, activities, and expected outputs from the model. Finally the memo ends with some suggestions for future research into effects-based assessment.

II. Working Definitions. The following working definitions are used in this memo. None of these definitions are canonical. Where appropriate, the working definition also provides some explanation on how it differs from other available definitions.

Model: a stylized representation of reality whose level of detail is determined by the required use of the model. The structure of the model consists of the rules, generally expressed as IF – THEN – ELSE statements and the type of information required by the rule statements. The actual information is separate from the model. Finally BECAUSE statements are added to the rule statements to support causal linkage assessment.

Assessment: the set of integrated and coherent activities that determine the results, and the effectiveness of those results, from the execution of operations. Memo this limits assessment to post-execution and ignores the critical need for assessment activities that predict the likely results of plans. This is sometimes referred to as 'plan critique'. This narrow definition also ignores the 'planning for assessment' activities that must take place before post-execution assessment can take place. Both these admittedly crucial activities are outside the scope of this research memo.

Effects-based: a mindset and set of processes that focuses on outcomes, results, or effects of actions (either direct or indirect) and the cause of those results rather than on the actions themselves.

Effects-based Assessment: the set of activities that determine the results (outcomes or effects), and the effectiveness of those results, from the execution of operations beyond the immediate results of those operations.[1] The March 2004 CAF (Combat Air Forces) White Paper, "Effects-Based Assessment: Closing the Loop" does not expressly define EBA. It views EBA as the combination of tactical assessment, component effects assessment, and operational effects assessment. These definitions appear to add more detail to the working definition used here but do not conflict in any way with the working definition used here. The March 2004 Draft AFDC (Air Force Doctrine Center) White Paper, "The Effects-based Approach to Conflict" states that assessment consists of all efforts to evaluate performance and progress. This definition appears much more general than the working definition used in this memo but again does not appear to conflict in any way with the working definition used here. It is worth noting, however, that both the CAF and AFDC white papers emphasize that post-execution assessment (the focus of this research memo) is not done or should not be viewed in isolation from planning, execution or plan critique activities. This meshing of planning, execution, and assessment is a constant theme in this research memo even though the focus of the memo is on a model for post-execution effects-based assessment.

III. Explanation. This section places EBA within the context of current combat assessment practices. The main point here is that EBA does not completely replace current practice but rather

[1] The Joint and canonical concept is called *combat assessment* and is defined as "The determination of the overall effectiveness of force employment during military operations." See JP 1-02. The CAF and AFDC definitions are used here for comparison because they both seek to address issues of *effects assessment* whereas Joint doctrine, at least so far, is silent on this question.

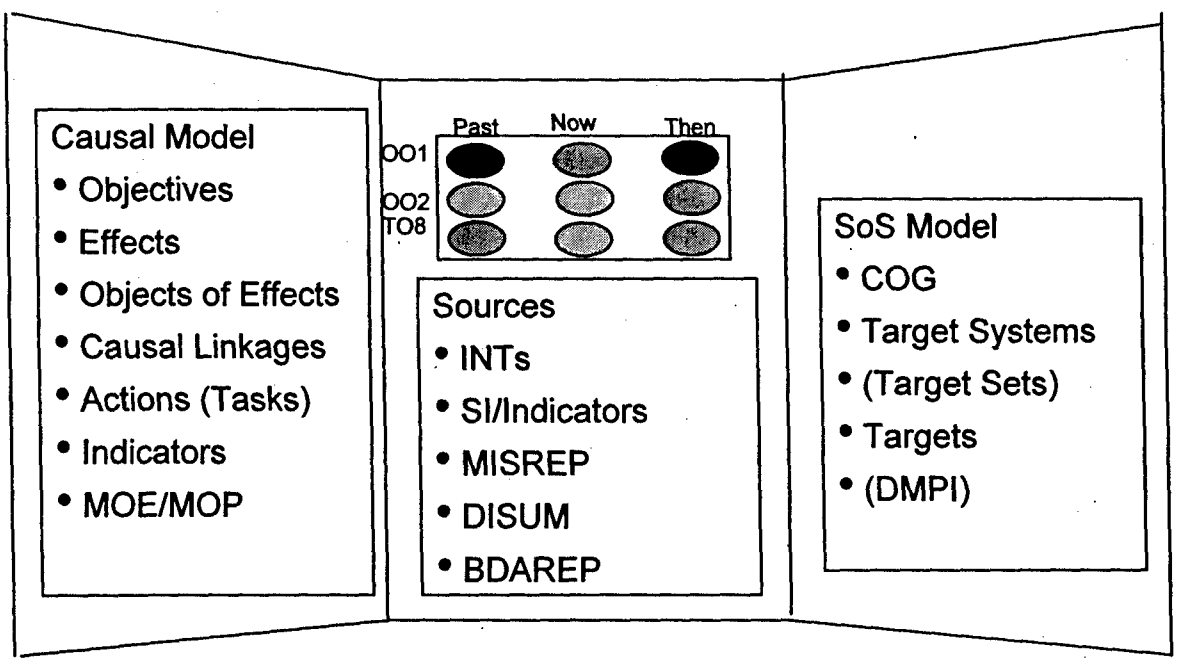
builds upon it to produce a more complete assessment picture. In this, EBA is the same as effects-based planning (EBP) which is best viewed as an extension to, and modification of, the current Joint Estimate Process rather than a completely new set of processes.

a. Current Practice: Combat Assessment. According to Joint Publication 3-60, *Joint Doctrine for Targeting*, Combat Assessment (CA) is the sixth and final phase of the Joint Targeting Cycle. It consists of two parts: battle damage assessment (BDA) and munitions effectiveness assessment. The result of these two processes is a reattack recommendation or a requirement for future target development. The main interest for this research memo is the BDA processes. Overall, the CA process is designed to determine whether the Joint Force Commander's desired effects on the adversary, as envisioned in the campaign plan, are being achieved. BDA supports this goal by taking a three level approach from the micro to the macro view of the adversary. These levels are described in more detail below. The last point about current practice to emphasize is the close connection between CA and planning. During planning measures of effectiveness (MOE) and performance (MOP) are developed and these are used during CA in determining whether the Commander's goals are being achieved or not.

b. Effects-based Assessment. EBA builds on these two CA principles: BDA reports that examine the effects on an adversary across multiple levels and the use of measures to ascertain progress towards attaining the Commander's desired effects. Fundamentally EBA adds to these principles one that deals with explaining the linkage between actions and effects. Furthermore, besides classic MOE and MOP information, EBA specifies beforehand the evidence of actions, causal linkages, and outcomes (or effects). These pre-determined bits of information are collectively referred to as 'Indicators'. The basic EBA process is by marrying the Indicators, MOE and MOP—that is, the evidence, measures and criteria—with the BDA reports that provide the impact on the adversary from the target through the target system level, a more complete picture of the impact of military actions on the adversary is provided. More detail on this process is provided below. Readers will memo the term 'fusion' is avoided here. While it might be technically correct, fusion has a specific technical meaning that is much narrower than the idea advanced here. Fusion is definitely required but more than fusion is needed to fulfill the concept of EBA advanced in this research memo.

c. Summary of Major Differences. Because effects-based plans are richer in content than classic plans, there is correspondingly more information required to accomplish effects-based assessment.

This increased information requirement cuts both ways. On the one hand, it is often commented that commanders are 'data rich but information poor'. In such an environment, adding additional information requirements seems likely to make a bad situation worse. On the other hand, because more data is presumably available than previously, at least the potential exists that more, and perhaps better, information could be made available to a commander. The second difference between classic CA and EBA is more fundamental. The traditional approach to CA has been called 'rollup' because the findings at lower levels, such as the MOP and physical effect levels, are 'rolled up' to higher and higher levels based solely upon what was planned.[2] This seems premised on the principle that the planners got the decomposition from objectives to tasks correct so that if the tasks were successfully accomplished then *ipso facto* the objectives were accomplished. Unfortunately the historical record does not support such optimism. EBA attempts to remedy this defect by specifically identifying the evidence that would support the causal chain from action to effect to specifically include looking for evidence to ascertain the correctness of the anticipated causal linkage (or mechanism) between action and effect.



OO = Operational Objective; TO = Tactical Objective

[2] Unfortunately, this approach is also advocated in the CAF White Paper on EBA. See p. 7.

IV. EBA Model. This section provides the EBA model in the form of a matrix (called EBAM). See Figure. The genesis of this matrix is the Target Value Matrix described in Joint doctrine.[3] This form was chosen because it allows depiction of the EBA elements, described briefly above and more fully here, and their relationships. The matrix is described in terms of inputs, activities, and outputs. This allows the matrix to be transformed into IDEF ICOM products[4] if desired. The architecture could then be expanded by adding applications or technologies that would support the resulting activity models.

a. Inputs: An effects-based plan. The input into EBAM is the causal model built during effects-based planning. The details of that model are:

Effects. This is the outcome anticipated from the action (direct Effect) or the result from previous actions (indirect Effect) or some combination of actions and previous results (cumulative Effect). The action or previous result (or some combination) comprise the IF while the direct, indirect, or cumulative Effect comprise the THEN forming the basic IF – THEN relationship. Example: IF the bomb explodes where targeted, THEN the bridge is destroyed. The sentence is generally written, however, as "The bridge is destroyed" as a statement of Effect.

Objects of Effects: Role of System-of-Systems analysis (SoSA). Systems analysis (also called network analysis, target systems analysis, or system-of-systems analysis) is crucial for an effects-based approach to planning, execution, and assessment. It is how indirect and cumulative Effects are predicted during planning and how outcomes are assessed beyond first-order physical effects. SoSA provides the objects for the desired effect. In the example above, 'bridge' was the object of the effect. According to Joint doctrine, a target system is one where targets are functionally related and that relationship is such that an effect on one target in the system will produce some effect on the system as an entity. Hence target systems can first, be functionally decomposed. Secondly, target systems exhibit dependency both within themselves and between themselves and other target systems. This is referred to in Joint doctrine and "intra-dependency" (within themselves) and "inter-dependency" (between themselves and other target systems). Research also shows there are causal relationships both within and between target systems. That is, a

[3] See JP 2-01.3.
[4] Inputs, Controls, Outputs, Mechanisms.

change in state of one element causes a change in state of one or more other elements. In summary, target systems or SoSA must show the elements of a system (generally called 'nodes') and three relationships (generally called 'links'): functional, dependent, and causal.[5]

Causal Linkages or Mechanisms. Causal linkages are explanations that state why the actions (or previous actions or indirect Effects) will result in the anticipated outcome. Generally these are expressed in a probabilistic manner with the probabilities proportionately decreasing from the first-order physical effect level to the n-order, mainly behavioral, effect level such as that associated with strategic outcomes. Causal linkages provide the BECAUSE element in IF – THEN statements.

Timing. While not technically an element in an effects-based plan (any plan requires some idea of time), timing plays an especially crucial role in EBP and hence in EBA. This is because of *delay* and *persistence*. Delay is the time from action to effect. This can be straightforward when dealing with direct actions and first-order physical effects but can become quite complicated when dealing with cumulative effects. The impact on EBA is clear. Information may be available from near instantaneous to several days; however, the desired effect may not be present (or, and this is a different timing calculation, observable) within those timelines. This could lead to a false negative assessment. Persistence is the time an effect lasts without further input. Again, the more complex the effect sought, the more complex the calculation required.

Indicators. As defined above, Indicators provide the evidence planners anticipate will show the various elements in the causal model. There can be various types of evidence sought depending on the nature of the element. This variety provides collection managers more options in assembling the competing tasks for their scarce intelligence gathering assets. It is preferable that the evidence sought be of the type that can be observed but that is not a firm requirement. There are Indicators of each element of the causal model from the tactical task level up through the campaign objectives and effect level.

[5] A useful model for this process can be found in Joe Strange, "Center-of-Gravity & Critical Vulnerabilities," *Perspectives on Warfighting*, Number 4, Second Edition, Marine Corps University, 2002 (1996).

b. Process: Marrying Indicator data with BDA. This subsection title sums the basic process of EBA. Indicators were discussed above. Now the attention turns to the other sources of information used to conduct EBA and closes with some techniques that can be employed.

1) Levels of BDA. The main information sources other than Indicators are Mission Reports (MISREPS) and battle damage assessment reports (BDAREPS). While MISREPS are useful in conducting operational level assessments, e.g., component effects assessment and operational effects assessment, they are most useful in tactical effects and events assessment and are not further discussed here. There are three phases of BDA and each produces a corresponding level of battle damage assessment provided via a specific BDAREP. The first phase is Physical Damage Assessment (PDA). It is an estimate of the quantitative extent of physical damage done to a specific target (or node in a target system). According to JP 2-01.1, "Some representative sources for data necessary to make a physical damage assessment include the air tasking order (ATO) or master air attack plan, MISREPs, aircraft cockpit video (ACV), weapon system video (WSV), visual/verbal reports from ground spotters or combat troops, controllers and observers, artillery target surveillance reports, SIGINT, HUMINT, IMINT, MASINT, and open-source intelligence (OSINT)." The second phase is Functional Damage Assessment (FDA). It is an estimate of the target's ability to perform its intended function. FDA is inferred from PDA and other sources of information. FDA also includes some estimate of how long the target required to recuperate from its current status to its pre-attack functional capability. The last phase of BDA is target system assessment. This provides a broad evaluation of the effectiveness of the military force applied against the target system in relationship to the effect desired.

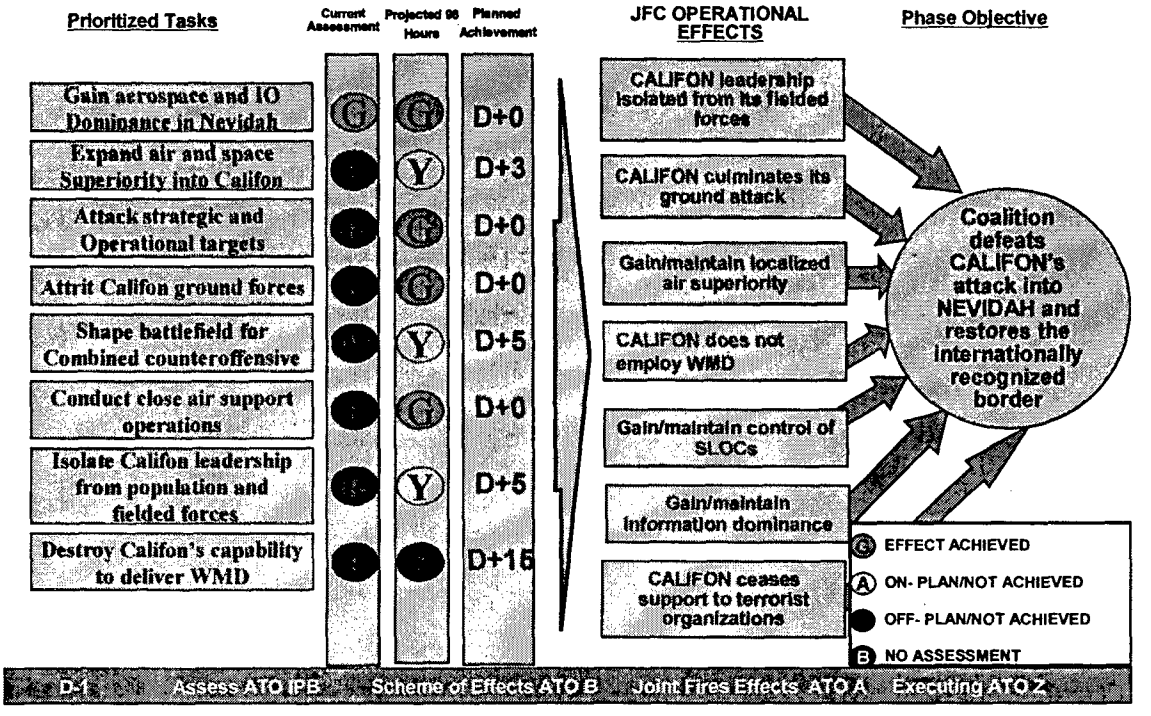
2) Marrying information: Quantification & Qualification. As shown, Indicator, BDAREP and other sources of information comes in a variety of media and formats from video to freeform text to numbers. Combining these is not a trivial problem. Current practice is a manual process supported, if at all, by MS Office applications. The technique offered here uses information extraction techniques, coding techniques, and an ontology base. The process starts with taking the extracted information and matching it against the ontology base to gain a common semantic, machine readable, formal language rendition. This is codified to allow statistical manipulation of the information to support inferential reasoning. The resulting data is combined with the already-provided quantified data then

analyzed using standard inferential statistical reasoning techniques. The challenge to this technique, of course, is the ontology base. While difficult in any case, providing ontology for behavioral effects is especially daunting. While efforts are underway, they are far from complete. Once the coding and statistical manipulation is complete, the information is plugged back into the causal model where tools used for plan critique can now be used for post-execution assessment.

c. Outputs: Status, Problems & Opportunities. Presenting the analyzed information is normally done via 'stoplight charts' where red, yellow, green, and blue circles are generally displayed in a time-series to show past accomplishment, present status, and predicted future state at each objective and effect level. The top figure below shows an example used during JEFX04. The bottom figure below shows an example of what was used by CDRUSCENTCOM during Operation IRAQI FREEDOM.

The use of inferential statistical methods also allows presenting confidence levels with the assessment. Finally, drilldown techniques allow assessors to examine in detail where problems may have arisen in the plan. Less often those techniques provide any suggestions on how to remedy those problems. Even rarer are techniques that use operational-level assessment to identify opportunities. AFRL's causal analysis tool (CAT) is an exception to this.

CFACC
OPERATIONAL PHASE II OBJECTIVES



	Regime Stable		Regime Unstable		Regime Collapse
LEADERSHIP	Coherent Message Presence Governance Command and Control	Increased Rhetoric Few Leaders Visible Some Degraded Command and Control	Reliant on Lies Calls for Sacrifice	Calling on Citizens to Die for Cause Leadership Disappearing Use of Weapons of Mass Destruction	Regime Command, Control and Communications Destroyed New Leadership Emerging
SECURITY APPARATUS	Control over Population Military Control Security Apparatus Functioning	Influence / Control Degraded	More Visible Control Attempts	Increase of Security Measures / Retribution	Fear / Power Base Destroyed
MILITARY	Volunteer / Special Forces Conscript / Regular Army	Regular Army Capitulating		Volunteer / Special Forces' Resistance Collapsing	Armed Forces Not Resisting
POPULATION	Capital City Ambivalent Area Supportive Area	Uncertain Level of Support for U.S. No Interference with U.S. Actions	Accept U.S. Actions Covert Support for U.S. Actions	Civil Disobedience Overt Support of U.S. Actions	Active Support of U.S. Actions

V. Areas for Further Research. This quick survey on one approach to EBA points out three areas needing further investigation. These areas are not the only ones needing further investigation nor do they solely need research only within the context of EBA. Rather these three were chosen as essential to completing the operational requirements that derive from the EBA approach offered here. The first deals with system-of-systems analysis. The main issue here is finding ways for commensuration of disparate engineering and logical models such that inter-dependency and causal relationships can be examined together and predicted outcomes identified. The second area is covered under the broad title of fusion of data not only from disparate data sources but from disparate media types and with a variety of pedigrees, levels of ambiguity, and missing elements. Finally, further research is needed into the processes of bringing all the various elements of EBA together such that they are integrated and coherent, both internally (as part of EBA) and as one element in an effects-based approach to planning, executing, and assessing operational-level operations.

Glossary

ACV	Aircraft cockpit video
AFDC	Air Force Doctrine Center
AFRL	Air Force Research Laboratory
ATO	Air tasking order
BDA	Battle damage assessment
CA	Combat assessment
CAF	Combat air forces
CAT	Causal analysis tool
CFACC	Coalition Forces Air Component Commander
EBA	Effects-based assessment
FDA	Functional damage assessment
HUMIT	Human intelligence
IMINT	Image intelligence
IO	Information operations
JEFX	Joint Expeditionary Force Experiment
JP	Joint publication
MASINT	Measurements and signatures intelligence
MISREP	Mission report
MOE	Measure of effectiveness
OSINT	Open source intelligence
PDA	Physical damage assessment
REP	Report
SIGNINT	Signals intelligence
WMD	Weapons of mass destruction
WSV	weapon system video